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Retrospective Study

Socio-demographic factors impact time to discharge following total knee arthroplasty

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Abstract

AIM

To determine social, logistical and demographic factors that influence time to discharge in a short stay pathway (SSP) by following total knee arthroplasty (TKA).

METHODS

The study included primary TKA's performed in a high-volume arthroplasty center from January 2016 through

December 2016. Potential variables associated with increased hospital length of stay (LOS) were obtained from patient medical records. These included age, gender, race, zip code, body mass index (BMI), number of pre-operative medications used, number of narcotic medications used, number of patient reported allergies (PRA), simultaneous bilateral surgery, tobacco use, marital status, living arrangements, distance traveled for surgery, employment history, surgical day of the week, procedure end time and whether the surgery was performed during a major holiday week. Multivariate step-wise regression determined the impact of social, logistical and demographic factors on LOS.

RESULTS

Eight hundred and six consecutive primary SSP TKA's were included in this study. Patients were discharged at a median of 49 h (post-operative day two). The following factors increased LOS: Simultaneous bilateral TKA [46.1 h longer ($P < 0.001$)], female gender [4.3 h longer ($P = 0.012$)], age [3.5 h longer per ten-year increase in age ($P < 0.001$)], patient-reported allergies [1.1 h longer per allergy reported ($P = 0.005$)], later procedure end-times [0.8 h longer per hour increase in end-time ($P = 0.004$)] and Black or African American patients [6.1 h longer ($P = 0.047$)]. Decreased LOS was found in married patients [4.8 h shorter ($P = 0.011$)] and TKA's performed during holiday weeks [9.4 h shorter ($P = 0.011$)]. Non-significant factors included: BMI, median income, patient's living arrangement, smoking status, number of medications taken, use of pre-operative pain medications, distance traveled to hospital, and the day of surgery.

CONCLUSION

The cost of TKA is dependent upon LOS, which is affected by multiple factors. The clinical care team should acknowledge socio-demographic factors to optimize LOS.

Key words: Total knee replacement; Total knee arthroplasty; Cost; Risk factors; Length of stay

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Core tip: In an effort to decrease post-operative length of stay (LOS), many institutions continue to develop optimal discharge pathways. Since LOS is dependent upon many variables, we sought to define which socio-demographic factors influence LOS in total knee arthroplasty (TKA). Six factors were found to increase LOS: Age, gender, Black or African American race, simultaneous bilateral TKA, later procedure end times and number of PRA. Two factors decreased LOS, patient being married and surgery during a major public holiday week. While none of the patient specific factors are modifiable by the clinician, we do have the ability to optimize surgical schedule and allocation of resources.

Ihekweazu UN, Sohn GH, Laughlin MS, Goytia RN, Mathews V, Stocks GW, Patel AR, Brinker MR. Socio-demographic factors impact time to discharge following total knee arthroplasty. *World J Orthop* 2018; 9(12): 285-291

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INTRODUCTION

Increased utilization of total joint arthroplasty (TJA) is expected to result in a pronounced economic burden on the United States health care system^[1]. Subsequently, cost reductions even at the individual case level can translate into a substantial cost savings to the overall system^[2]. In-hospital length of stay (LOS) has been shown to directly influence the total cost of joint arthroplasty when patients are discharged home^[3,4]. Since LOS is a modifiable cost factor, increased focus has been placed on implementing measures that aim to discharge patients from the hospital as soon as safely possible. The recent development of short stay pathways is a direct result of advancements in surgical, anesthetic and rehabilitation techniques. While there are concerns regarding the overall safety of short stay pathways (SSP) compared to conventional postoperative pathway (CPP), the literature suggests that drastic reductions in LOS can be accomplished without increasing complication rates^[5].

Factors influencing LOS such as age, gender and perioperative complications have been previously described in the literature under CPP for hip and knee arthroplasty^[6,7]. At the earliest, patients in these CPP studies were discharged on the 3rd day following surgery^[6-8]. Keswani *et al*^[8] found that patients with later surgical start times and end of the week procedure days (Thursday and Friday) had longer LOS in a CPP. However, a separate study performed at an institution utilizing a SSP found that surgical day of the week had no correlation with LOS^[9]. Another institution utilizing SSP investigated the influence of preoperative patient characteristics and perioperative surgical factors related to prolonged LOS^[10,11]. Regardless there remains limited data on the factors influencing LOS following TKA in a SSP.

The primary purpose of this study was to assess the influence of social, logistical and demographic factors on time to discharge in a SSP for TKA. The findings from this study may further enhance preoperative and perioperative risk stratification models that already incorporate patient characteristics and perioperative surgical factors but neglect other potentially influential variables.

MATERIALS AND METHODS

Methods

A retrospective chart review was performed for a consecutive series of 806 elective primary TKA's performed at a single specialty hospital from January

2016 to December 2016. All procedures were performed by one of 3 experienced surgeons, each performing more than 250 TKA's per year. All surgeries, regardless of LOS, were performed using the hospital's SSP for each phase of care. This study was evaluated and an Institutional Review Board (IRB) exemption was given for this work by the Texas Orthopedic Hospital IRB (TOH203e).

Short stay protocol

All patients at this institution undergo a formal pre-operative screening process to ensure they are safe for surgery and postoperative care within our specialty hospital. Active renal replacement therapy, active lung disease requiring home oxygen support, or active cardiac disease requiring a defibrillator exclude the patient from surgery at this institution. Each patient is medicated preoperatively with celecoxib 200 mg, Neurontin 100 mg, and acetaminophen 650 mg. Intra-operative anesthesia consists of a propofol infusion with no inhalation anesthetic and no muscle relaxation. During the procedure a periarticular anesthetic of weight-based ropivacaine 0.5% and morphine 5-10 mg is injected into the soft tissues prior to closure. All patients are given 1 g intravenous (IV) tranexamic acid prior to incision and 1 gram prior to closure, unless it is contraindicated, at which point it is administered topically. Post-operative medication regimen consists of a combination of hydrocodone, tramadol, methocarbamol, dexamethasone and IV ketorolac. Deep vein thrombosis prophylaxis consists of aspirin or rivaroxaban per surgeon discretion and is continued for 4 wk. Patients are mobilized approximately 2 h after surgery with physical therapists. Standing is attempted, and if tolerated, patients are allowed to walk with a walker and assistance as far as they can tolerate. Continuous passive motion devices were used during the study period per surgeon discretion. The following morning patients undergo their second session with the physical therapists. The three surgeons included in this study independently round on their patients on all days, including weekends and holidays. Patients were discharged as soon as they had adequate oral pain control, are safe to ambulate and mobilize with an assistive device and are hemodynamically stable.

Study outcomes

Potential variables associated with increased hospital LOS were obtained from patient medical records. These included age, gender, race, zip code, body mass index (BMI), number of pre-operative medications used, number of narcotic medications used, number of patient reported allergies (PRA), simultaneous bilateral surgery, tobacco use, marital status, living arrangements, distance traveled for surgery, employment history, surgical day of the week, procedure end time and whether the surgery was performed during a major holiday week. Thanksgiving, Christmas and New Year's Eve were the major holidays included in the study. The patient's zip

code was used to obtain the median household income of the zip code from the 2016 American Community Survey performed by the United States Census Bureau^[12].

Baseline demographics, surgical factors, and social factors were summarized by mean (\pm SD) for continuous factors or by count and percentages for categorical factors in order to characterize the study population. Multivariate regression analysis was performed to determine the contribution of demographic, logistical and social factors on LOS. A stepwise model was used to determine the number of factors significantly associated with LOS. Statistical significance was defined as $P < 0.05$ and SPSS 24 (IBM Corp., Armonk, NY, United States) was used for statistical analyses.

RESULTS

A total of 806 primary TKA cases were included in the study. There were 491 female (60.9%) patients and the average age of the study population was 64.5 years. 76.6% of the study population were identified as White, 11.4% as other, 7.8% black/African American, 2.2% identified as Asian and 1.9% declined to state. The median LOS was 49.0 h with a range from 18-236 h. All subject characteristics that were included in the analysis are depicted in Table 1.

In our study population, the constant (or baseline regression model) for LOS was 22.7 h ($P = 0.004$). Adding or subtracting beta coefficients for other factors predicts individual patient LOS. Multiple regression identified six factors that increased LOS (Table 2): Simultaneous bilateral TKA [46.1 h longer ($P < 0.001$)], female gender [4.3 h longer ($P = 0.012$)], age [3.5 h longer per ten-year increase in age ($P < 0.001$)], number of PRA's [1.1 h longer per each reported number of allergies ($P = 0.005$)], later procedure end-times [0.8 h longer per hour increase in end-time ($P = 0.040$)] and Black or African American patients [6.1 h longer ($P = 0.047$)]. Two factors were found to decrease LOS: Patients being married [4.8 h shorter ($P = 0.011$)] and TKA's performed during major holiday weeks [9.4 h shorter ($P = 0.011$)]. Non-significant factors included: BMI, median income, patient's living arrangement, smoking status, number of medications taken, use of pre-operative pain medications, distance traveled to hospital, and the day of surgery.

DISCUSSION

LOS is a modifiable cost factor in the overall expense of TJA. Increased emphasis has been placed on both employing SSP and optimizing risk stratification models that identify those who may or may not be appropriate candidates for SSP. Our study identified simultaneous bilateral TKA, female gender, increased age, increased number of PRA, later surgery end time and race identified as Black or African American as factors that increased LOS. Two factors, patient being married and procedures

Table 1 Baseline subject characteristics

Factor	mean \pm SD or n (%)
Number of patients	806
Gender	
Male	315 (39.1)
Female	491 (60.9)
Age (yr)	64.5 \pm 8.5
Race	
Asian	18 (2.2)
Black/African American	63 (7.8)
White	617 (76.6)
Other	94 (11.4)
Decline to state	16 (1.9)
Body mass index	33.81 \pm 7.4
Employed	347 (43.1)
Median income by zip code	\$66586 \pm 25562
Marital Status	
Single	105 (13.0)
Married	593 (73.6)
Widow/widower	66 (8.2)
Divorced	42 (5.2)
Patient lives alone (Y)	99 (12.3)
Smoker	
Current	68 (8.4)
Former	232 (28.8)
Never	506 (62.8)
Number of allergies	1.5 \pm 2.2
Number of medications	6.1 \pm 4.8
Pre-operative pain meds (Y)	108 (13.4)
Simultaneous bilateral total knee arthroplasty	37 (4.6)
Distance from hospital (miles)	61.95 \pm 122.8
Day of surgery	
Monday	242 (30.0)
Tuesday	175 (21.7)
Wednesday	129 (16.0)
Thursday	194 (24.1)
Friday	61 (7.6)
Saturday	5 (0.6)
Holiday week surgery	43 (5.3)
Surgery end time (h:min)	11:05 \pm 2:22

performed during major holiday weeks decreased LOS.

Increased age and female gender are factors that are known to correlate with increased LOS in SSP^[11,13]. Both simultaneous bilateral TKA^[14] and patient identified race as non-Caucasian^[15] have been shown to increase LOS in CPP as well as SSP. Our data showed that patients identifying as Black or African American had a significantly longer LOS after TKA, while other racial groups (White and Other) showed no difference in LOS. Racial disparities in utilization, complication rates and outcomes of arthroplasty are prevalent in the literature^[15-17], however, race is often confounded with socioeconomic factors. In our study, Black patients had a longer LOS but median household income was not a significant factor influencing LOS. Further analysis showed that the median income of Black patients in our study was just over \$41000 while both White and Other patients was over \$60000 (Figure 1). According to the American Community Survey the median income for the United States in 2016 was \$55322^[12], so in our patient population Black patients were well under the United States median income while White and Other

patients were slightly above. Thus, increased LOS in Black patients may not be entirely due to race, as socioeconomic factors may also be confounded by race. Future studies will need to further define the complex relationships between race, socioeconomic status, perioperative outcomes and LOS in TJA.

To our knowledge, marital status has not previously been shown to demonstrate any influence on LOS following TKA. While limited, the literature outside of orthopedics suggests that being married may be associated with better treatment outcomes^[18,19]. However, marital status has been shown to affect outcomes following TKA as patients that are married have better overall outcomes following TKA^[20]. In our study, married patients had a decreased postoperative LOS. Our findings corroborate the general trend in the literature, with a positive association between being married and improved treatment outcomes. Notably, marital status has recently been identified as a key variable that should be investigated in future research on outcomes of knee and hip surgery^[21].

Prior studies indicate that increasing amounts of PRA's is associated with worse outcomes following total hip and knee arthroplasty^[22-24]. Interestingly, the patient reported "allergy" is often a misnomer as only 15% of PRA's studied in a community hospital setting represented a true IgE mediate hypersensitivity reaction^[25]. In a study utilizing data from the Canadian Community Health registry, an association between mood and anxiety disorders and PRA reporting was demonstrated^[26]. As the relationship between PRA and psychiatric disorders is further elucidated, their impact on all aspects of TJA is becoming more apparent. In a prospective study of 446 patients undergoing primary hip and knee arthroplasty, Otero *et al*^[22] found that patients reporting at least 1 allergy had significantly lower postoperative SF-36 physical component score compared to those reporting no allergies. In a retrospective review, McLawhorn *et al*^[23] demonstrated that increasing number of PRAs was associated with both worse satisfaction and Western Ontario and McMaster Universities Arthritis Index scores, in addition to increased LOS following TKA in a CPP. The median LOS of the patients included in their TKA cohort was 4.0 d. Our study found that for each reported allergy, LOS increased by 0.8 h. While this may seem to be an insignificant amount of time, it is not uncommon to encounter patients with many PRAs in practice; in our study, one patient reported twenty-three. In an SSP, increasing the LOS by just a few hours may represent the difference in an additional day spent in the hospital.

The relationship between surgical day of the week and LOS has previously been studied in both CPP and SSP. In separate retrospective reviews, both Muppavarapu *et al*^[27] and Keswani *et al*^[8] found that patients who underwent TJA or total hip arthroplasty (THA) respectively, on Thursday or Friday had significantly longer hospital LOS compared to patients undergoing those procedures earlier in the week. These two studies represented a CPP as the LOS of the patients included these studies was

Table 2 Significant factors predicting length of stay

Factor	Beta coefficient (h) ¹	Std. error	P value
Constant	22.7	7.8	0.004
Simultaneous bilateral total knee arthroplasty	46.1	4.1	< 0.001
Gender (female)	4.3	1.7	0.012
Age (per 10 yr)	3.5	1.0	< 0.001
Patient is married	-4.8	1.9	0.011
Number of allergies	1.1	0.4	0.005
Holiday week surgery	-9.4	3.6	0.011
Surgery end time	0.8	0.4	0.040
Black/African American	6.1	3.0	0.047

¹In our study population, the constant for length of stay (LOS) was 22.7 h. Adding or subtracting beta coefficients for other factors predicts individual patient LOS.

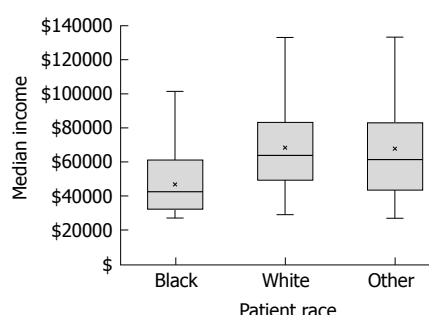


Figure 1 Median income level by race with the bold horizontal line representing the median, the box shows the 25% to 75% range, the x is the mean and the whiskers represent the entire range of the data.

greater than 3 d. A comprehensive PubMed search found only one study that investigates the effect of surgical day of the week on LOS in an SSP for total joint arthroplasty. In a cohort of patients with an average LOS of < 2 d, Edwards *et al*^[9] found that surgical day of the week did not influence time to discharge. Our results were similar as surgical day of the week did not influence LOS in our SSP. These findings suggest that as LOS decreases the overall impact of performing a procedure towards the end of the week may diminish.

The influence of surgical start time on LOS has been investigated across several surgical subspecialties with the evidence suggesting that as cases begin later in the day, LOS increases^[28,29]. Earnest *et al*^[28] suspected that initial post-operative care is delayed for patients admitted in the afternoon because clinical workup and management usually occurs in the morning. Only one study has investigated the influence of surgical timing on LOS in total joint arthroplasty. In a cohort of THA patients receiving conventional postoperative care pathways, Keswani *et al*^[8] found that procedures starting after 2 PM were associated with longer LOS compared to procedures starting prior to 2 PM. We found that LOS was slightly shorter for every hour later the procedure ended. In our institution's SSP, post-operative protocols do not depend on the time of day as staffing is consistent between shifts. Patients are encouraged to work with a physical therapist just a few hours after surgery when clinically feasible. Our findings suggest that unlike CPP, in SSP the

surgical start time of the procedure is less critical.

The relationship between public holidays and LOS across all medical fields has never been reported, a few studies have sought to understand the influence of holidays on clinical outcomes and readmission^[30-32]. In our study, patients undergoing TKA during major public holiday weeks were found to have decreased LOS as compared to patients having surgery during a normal week. Several factors likely influence these findings including patient, surgeon and staff related variables. As our study included three surgeons, the most senior surgeon performed fewer procedures during holiday weeks and also had a slightly higher LOS average, possibly confounding the lower LOS holiday week results. While these results do leave room for speculation, the present study could not delineate any additional conclusions from these findings; therefore this is an area that future studies should consider investigating further.

Our study had several limitations. First, the data used was retrospectively collected and therefore susceptible to inherent bias in its analysis. Secondly, race identification was limited to what was reported in the chart and the 'other' classification likely encompassed a variety of distinct ethnicities that could not be further discerned. Third, there was potential for type II statistical error as certain variables approached but did not reach significance in this study. As it pertains to LOS, several variables that were originally thought to be relevant factors were not. In particular, distance traveled and pre-operative narcotic use did not reach significance in our cohort.

In an effort to decrease post-operative LOS, many institutions continue to develop optimal discharge pathways following TKA. Since LOS is dependent upon many variables, we sought to define which social, logistical and demographic factors influence LOS in TKA. Six factors were found to increase LOS in a SSP: Age, gender, Black or African American race, simultaneous bilateral TKA, later procedure end times and number of PRA's. Two factors decreased LOS in an SSP, patient being married and surgery during a major public holiday week. While none of the patient specific factors (*e.g.*, age, race, gender, marital status, socioeconomic status,

and PRA's) are modifiable by the clinician, we do have the ability to optimize surgical schedule and allocation of resources. When refining predictive models for LOS, in addition to considering known clinical factors, the care team should also appreciate the extent that social, demographic and logistical factors influence LOS. Furthermore, the influence of these factors may depend on whether a CPP or an SSP model is being employed.

ARTICLE HIGHLIGHTS

Research background

Time to discharge or in-hospital length of stay (LOS) has been shown to directly influence the total cost of joint arthroplasty when patients are discharged home. Since LOS is a modifiable cost factor, increased focus has been placed on implementing measures that aim to discharge patients from the hospital as soon as safely possible. The recent development of short stay pathways is a direct result of advancements in surgical, anesthetic and rehabilitation techniques. Traditional factors such as age, gender, comorbidities and perioperative complications have been studied extensively and influence LOS. Patient social, logistical and demographic factors are non-modifiable factors but potentially influence LOS.

Research motivation

The motivation behind this research was to further improve short stay pathways by evaluating non-traditional factors that potentially could influence LOS. Our hypothesis was that social, logistical and demographic factors influence LOS following total knee arthroplasty (TKA) in a short stay pathway.

Research objectives

The primary purpose of this study was to assess the influence of social, logistical and demographic factors on time to discharge in a short stay pathway following TKA. The findings from this study may further enhance preoperative and perioperative risk stratification models that already incorporate patient characteristics and perioperative surgical factors but neglect other potentially influential variables.

Research methods

A retrospective chart review was performed for a consecutive series of 806 elective primary TKA's performed at a single specialty hospital from January 2016 to December 2016. Potential variables associated with increased hospital LOS were obtained from patient medical records. These included age, gender, race, zip code, body mass index (BMI), number of pre-operative medications used, number of narcotic medications used, number of patient reported allergies (PRA), simultaneous bilateral surgery, tobacco use, marital status, living arrangements, distance traveled for surgery, employment history, surgical day of the week, procedure end time and whether the surgery was performed during a major holiday week. Thanksgiving, Christmas and New Year's Eve were the major holidays included in the study. Baseline demographics, surgical factors, and social factors were summarized by mean (\pm SD) for continuous factors or by count and percentages for categorical factors in order to characterize the study population. Multivariate regression analysis was performed to determine the contribution of demographic, logistical and social factors on LOS.

Research results

Patients were discharged at a median of 49 h (post-operative day two). Six factors increased LOS: Simultaneous bilateral TKA, female gender, age, patient-reported allergies, later procedure end-times, and Black or African American patients. Decreased LOS was found in married patients and TKA's performed during holiday weeks. Non-significant factors included: BMI, median income, patient's living arrangement, smoking status, number of medications taken, use of pre-operative pain medications, distance traveled to hospital, and the day of surgery.

Research conclusions

The cost of TKA is dependent upon LOS, which is affected by multiple factors.

The clinical care team should acknowledge socio-demographic factors to further optimize short stay pathways and decrease LOS.

Research perspectives

In an effort to decrease post-operative LOS, many institutions continue to develop optimal discharge pathways following TKA. Since LOS is dependent upon many variables, we sought to define which social, logistical and demographic factors influence LOS in TKA. Six factors were found to increase LOS in a short stay pathway: Age, gender, Black or African American race, simultaneous bilateral TKA, later procedure end times and number of PRA's. Two factors decreased LOS: Patient being married and surgery during a major public holiday week. While none of the patient specific factors (e.g., age, race, gender, marital status, socioeconomic status, and PRA's) are modifiable by the clinician, we do have the ability to optimize surgical schedule and allocation of resources. When refining predictive models for LOS, in addition to considering known clinical factors, the care team should also appreciate the extent that social, demographic and logistical factors influence LOS.

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Observational Study

Humeral retroversion and shoulder muscle changes in infants with internal rotation contractures following brachial plexus birth palsy

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Informed consent statement: We received an IRB waiver from the Institutional review board since this was a retrospective observational study, utilizing MRI scans made strictly for clinical purposes. MRIs were all anonymized by the Radiology department before conducting our study. See the attached IRB statement.

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Abstract

AIM

To examine humeral retroversion in infants who sus-

tained brachial plexus birth palsy (BPBI) and suffered from an internal rotation contracture. Additionally, the role of the infraspinatus (IS) and subscapularis (SSc) muscles in the genesis of this bony deformation is explored.

METHODS

Bilateral magnetic resonance imaging (MRI) scans of 35 infants (age range: 2-7 mo old) with BPBI were retrospectively analyzed. Retroversion was measured according to two proximal axes and one distal axis (transsepicondylar axis). The proximal axes were: (1) the perpendicular line to the borders of the articular surface (humeral centerline); and (2) the longest diameter through the humeral head. Muscle cross-sectional areas of the IS and SSc muscles were measured on the MRI-slides representing the largest muscle belly. The difference in retroversion was correlated with the ratio of muscle-sizes and passive external rotation measurements.

RESULTS

Retroversion on the involved side was significantly decreased, 1.0° vs 27.6° (1) and 8.5° vs 27.2° (2), ($P < 0.01$), as compared to the uninvolved side. The size of the SSc and IS muscles on the involved side was significantly decreased, 2.26 cm^2 vs 2.79 cm^2 and 1.53 cm^2 vs 2.19 cm^2 , respectively ($P < 0.05$). Furthermore, the muscle ratio (SSc/IS) at the involved side was significantly smaller compared to the uninvolved side ($P = 0.007$).

CONCLUSION

Even in our youngest patient population, humeral retroversion has a high likelihood of being decreased. Altered humeral retroversion warrants attention as a structural change in any child being evaluated for the treatment of an internal rotation contracture.

Key words: Humeral retroversion; Infants; Brachial plexus; Brachial plexus neuropathies; Shoulder; Humerus

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Core tip: This study examines humeral retroversion in infants who sustained neonatal brachial plexus palsy and suffered from an internal rotation contracture. The existing common treatment options all strive for better function of the upper extremity through an improved position of the hand in space. Therefore, a thorough understanding of the development of the pathogenesis of this injury is important. We found a significant reduction of humeral retroversion in our study group (mean difference, 26.8). When treatment becomes warranted and contralateral humeral version measurements greatly differ, a humeral derotational osteotomy may offer the best improvement regarding the hand position.

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INTRODUCTION

The most common musculoskeletal sequela of neurologic injury of brachial plexus birth palsy (BPBI) is an internal rotation contracture of the shoulder. This contracture is frequently associated with deformity of the glenohumeral joint^[1-5]. These bony deformities have been thought to be a consequence of abnormal muscular development^[6-8].

The internal rotation contracture secondary to BPBI has been associated with alterations of humeral retroversion^[9-12]. Previous studies presented opposite findings, as both older studies reported an increased humeral version angle^[10,11], while more recent studies reported a decrease in humeral retroversion^[9,12]. Normal humeral retroversion is greatest at birth and gradually decreases through adolescence^[13-15] to adult values averaging between 25-30 with well documented individual variation^[16]. One well-studied exception is the throwing athlete, for whom retroversion has been shown to be greater on the dominant throwing side, due to repetitive throwing that usually begins in early childhood^[17-21].

The existing common treatment options consist of soft tissue procedures (releases and tendon transfers) and bone realignment procedures (rotational osteotomy) with the aim to provide better function of the upper extremity through an improved position of the hand in space^[22-26]. This position is directly related to the humeral version angle. We studied humeral retroversion in 35 consecutive infants who were under evaluation for treatment of their internal rotation contractures secondary to unilateral BPBI in this retrospective observational study. Our main goal was to further elucidate the timing that these anatomic changes may occur; therefore, we included our youngest patient population. We hypothesized that the retroversion angle (RV-angle) on the involved side would be significantly decreased relative to the uninvolved side and that the difference would increase with age. Since the subscapularis (SSc) and infraspinatus (IS) muscles, are an agonist-antagonist muscle pair regarding humeral rotation, we hypothesized that an imbalance between these muscles would correlate with altered humeral version.

MATERIALS AND METHODS

In this retrospective observational study, we included 37 Magnetic resonance imaging (MRI) -scans from a consecutive series of infants (< 1 year old) with a unilateral BPBI. All infants were potential candidates for neurosurgical interventions because of the severity of the

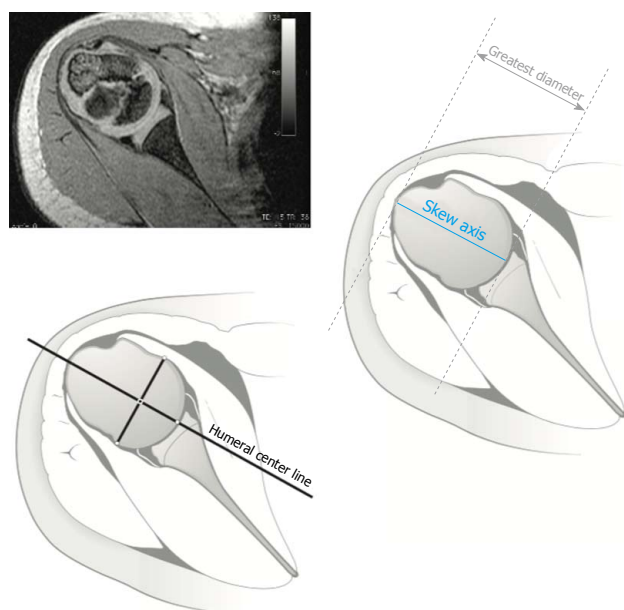


Figure 1 Schematic illustration of measurement parameters applied to a magnetic resonance imaging slice from the proximal part of the normal uninvolved humerus. (Reproduced with modification from: Pearl ML, *et al.* Geometry of the proximal humeral articular surface in young children: a study to define normal and analyze the dysplasia due to brachial plexus birth palsy. *J Shoulder Elbow Surg* 2013; **22**: 1274-84. Reproduced with permission from Elsevier.)

neurological lesion. This study was IRB approved.

MRI studies were performed on a 1.5-T MRI-unit (Magnetom 1.5 T Vision; Siemens, Erlangen, Germany). A FISP three-dimensional pulse acquisition sequence (repetition time, 25 msec; time to echo, 10 msec; flip angle 40°) with ranges from 0.8 to 1.5 mm partitions was used to obtain images from both shoulders and upper arms, representing the full humerus and glenohumeral joint in the axial plane. All children were given pethidine, droperidol and chlorpromazine intramuscularly. During sedation, they were monitored by electrocardiograph, measurement of oxygen saturation, and by video. Children were not moved during the imaging protocol.

From these 37 studies, two were insufficient for completing our detailed measurement protocol, as one study did not capture the entire humerus and motion artifacts compromised the other study.

Our Radiology department anonymized the MRI studies before performing our measurement protocol; Digital Imaging and Communications in Medicine files were imported as a numerical database into Osirix (Pixmeo, Geneva, Switzerland). For humeral version measurements, axial plane slides from the involved and uninvolved side that to our best efforts represented the midpoint of the humeral head were selected. For the measurement of muscle dimensions, axial plane slides representing the largest cross-sectional area of the SSc muscle and infraspinatus muscle were selected and exported as TIFF files. The TIFF files were imported into Geometer's Sketchpad version 5.03 (KCP Technologies, Emeryville, CA, United States) for further retroversion

analyses. The region of interest tool available in Osirix was used for muscle cross-sectional area measurements. The Narakas classifications were assigned as described by Narakas^[27]. Passive external rotation was measured with the arm in the adducted position and the elbow by the side.

Measure of retroversion

Retroversion was measured with respect to two different methods for the proximal humeral axis and the transepicondylar axis distally, introduced by Pearl *et al.*^[12].

The first proximal reference axis was chosen to provide continuity with earlier retroversion analysis performed in this specific patient group^[10,11]. This axis is conforming to the longest diameter through the humeral head. A line segment was created, which spanned the greatest distance from the periphery of the greater tuberosity to the medial articular surface and is labeled as the skew axis (SA) (Figure 1)^[2].

Retroversion was analyzed using the humeral center-line (HCL) as the proximal axis (Figure 1). This is a commonly used axis in various retroversion studies^[19,28-32]. The HCL represents the perpendicular projection from the margins of the articular surface.

Based on the literature, retroversion of the humeral head is shown as a positive value and anteversion is shown as a negative value. Two investigators performed the humeral version measurements.

Surface area measurements

Cross-sectional areas of the IS and SSc muscles were measured using the closed region-of-interest polygon tool in Osirix (Pixmeo). The MRI slides depicting the largest muscle bellies were identified for measurement of this cross-sectional area. Muscle size was determined by the muscle cross-sectional area in cm² and muscle percentage relative to the corresponding muscle at the uninvolved side. Furthermore, the ratio of the SSc and IS muscle (SSc/IS) was calculated to compare muscle balance between both sides and correlate these with the Δ RV-angle.

Analysis

Statistical analysis was performed using SPSS software (version 22.0; SPSS Inc., Chicago, IL, United States). The distribution analysis showed an approximately normal distribution.

Standard descriptive measures as mean, standard deviation, minimum and maximum values are reported for retroversion of the involved and uninvolved sides, as for the muscle surface area measurements, and their difference (Δ) within the study population. Pearson product-moment or Spearman rank correlation coefficients are estimated between each of these and passive external rotation and Narakas classification, as appropriate, based on the underlying distribution and type of the data. Paired data, such as involved vs uninvolved measurements regarding retroversion and muscle cross-sectional area measurements made on the same

Table 1 Demographics

Subject	Narakas	Age (mo)	External rotation (passive) (°)	Retroversion involved (HCL) (°)	Retroversion involved (SA) (°)	Retroversion uninvolved (HCL) (°)	Retroversion uninvolved (SA) (°)
1	3	2.6	-15	7.665	11.25	26.4	26.315
2	1	3.1	-5	-9.16	11.045	23.18	13.485
3	1	3.2	-40	-17.125	4.04	18.65	17.05
4	3	3.2	-30	14.175	23.395	30.56	31.865
5	3	3.3	0	-7.05	6.67	31.23	32.85
6	3	3.4	-10	-24.74	-19.26	41.72	31.705
7	3	3.4	0	7.67	7.905	30.145	29.165
8	3	3.5	-20	35.595	35.015	27.295	31.23
9	2	3.5	-5	-10.885	1.615	24.17	23.905
10	1	3.5	-20	4.54	2.05	32.21	26.49
11	3	3.6	-20	1.99	5.695	43.55	36.11
12	1	3.6	-20	3.6	22.565	54.905	47.955
13	3	3.8	-25	1.595	9.425	29.355	36.42
14	1	4.0	-5	-6.715	3.44	29.115	28.165
15	2	4.1	-15	-13.53	-1.035	21.59	25.605
16	1	4.1	-15	14.975	9.85	25.575	21.24
17	3	4.5	-25	0.065	-2.075	19.47	19.995
18	3	4.5	-45	24.195	20.195	34.19	34.55
19	1	4.5	-10	-4.115	6.1	24.305	20.175
20	2	4.6	-30	-7.205	11.675	13.465	14.06
21	3	4.6	-10	-3.14	7.29	15.445	12.14
22	1	4.7	-20	4.125	18.195	23.045	30.385
23	1	4.7	-20	-20.83	1.9	21.85	30.085
24	1	4.8	-40	4.875	9.95	15.655	20.11
25	3	4.9	-40	8.935	9.525	18.805	11.765
26	1	5.0	-15	38.24	33.53	20.055	15.945
27	1	5.0	0	-8.86	4.405	24.85	21.6
28	1	5.0	-15	-30.23	-20.135	38.975	23.31
29	1	5.0	-10	24.725	25.535	32.98	39.03
30	1	5.1	-5	8.79	10.05	20.115	-2.295
31	1	5.4	-20	-28.55	-11.965	47.445	39.185
32	3	5.6	-35	3.385	6.45	30.395	27.485
33	3	5.9	-15	-16.805	11.66	18.085	14.5
34	2	5.9	-30	11.89	7.225	28.56	35.075
35	1	6.5	-10	17.315	14.43	31.08	22.5
Mean		4.3	-18.3	0.8	8.5	27.7	25.4
Standard deviation		0.9	12	16.1	11.7	9.2	9.8
Minimum		2.6	-45	-30.23	-20.135	13.465	-2.295
Maximum		6.5	0	38.24	35.015	54.905	47.955

HCL: Humeral center-line; SA: Skew axis.

subject, were compared using paired t- or paired-samples Wilcoxon's signed-rank tests, as appropriate. Inter-rater reliability assessment by Intraclass correlations coefficient (ICC) was performed. A Bland-Altman plot was created to visualize potential differences in retroversion measuring methods^[33].

RESULTS

The 35 children included in our study had a mean age of 4.3 mo (range of 2.1-6.5 mo), and they were classified according to the Narakas classification: Narakas I : 18 cases; Narakas II : 4 cases; Narakas III : 15 cases. Internal rotation contractures varied from -45° to 12°, with a mean of -18°, measured as passive external rotation with the elbow by the side (Table 1).

Humeral retroversion by HCL

Retroversion measured according to the HCL and the

transepicondylar axis was significantly decreased on the involved side as measured by both observers. Mean RV-angles were 0.8° vs 27.7° ($P < 0.001$). Paired differences averaged 26.8°, with a range from -18.4° to 77.8°. Figure 2 shows the distribution of the measurements. In two patients, retroversion increased on the involved side (Table 1). Age did not correlate with a decrease in humeral retroversion ($r = -0.108$, $P = 0.538$).

Humeral retroversion by SA

Retroversion measured according to the SA and the transepicondylar axis was also significantly decreased on the involved side, as measured by both observers. Mean RV-angles were 8.5° vs 25.4° ($P < 0.001$). Paired differences averaged 17.5°, with a range from -22.2° to 53.3°. Figure 3 shows the distribution of measurements. In five patients, retroversion was increased on the involved side (Table 1). Age was again not correlated with a decrease in humeral retroversion ($r = -0.120$, $P =$

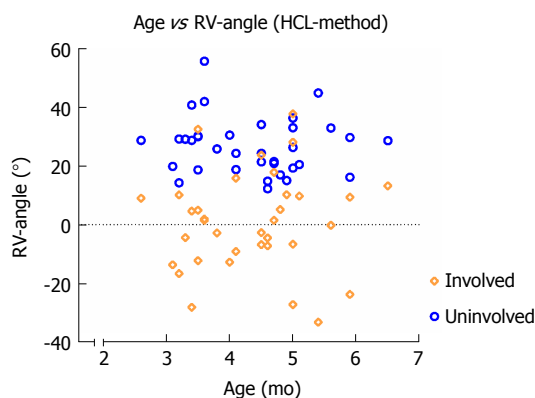


Figure 2 The distribution among measurements using the humeral center line as a proximal axis. HCL: Humeral center line; RV-angle: Retroversion angle.

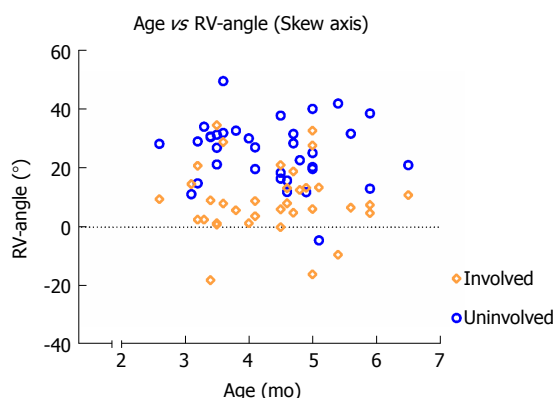


Figure 3 The distribution among measurements using the skew axis as a proximal axis. In the deformed humeral head, the skew axis yields systematically higher values compared to the humeral center line. RV-angle: Retroversion angle.

0.492).

Muscle surface area

Both muscles were significantly smaller on the involved side. The IS muscle measured a mean surface area of 2.35 cm² vs 2.84 cm² (83%) ($P < 0.001$), and the SSC muscle was 1.56 cm² vs 2.20 cm² (70%) ($P < 0.001$).

Furthermore, the muscle ratio (SSC/IS) on the involved side was significantly smaller compared to the uninvolved side ($P = 0.007$). In Table 2, the results of the muscle cross-sectional area measurements are summarized.

Correlations

Pearson's product correlation tests were performed for the retroversion measurements, the Δ RV-angle and the muscle area ratios and muscle surface area measurements, however no significant correlations were found on the involved side. When correlating age with decrease of retroversion, the Spearman Rho test was performed for retroversion measurement and Narakas' score and passive external rotation, no significant correlations were found ($P > 0.05$).

HCL method vs SA

For retroversion measured by HCL, the ICC for interrater reliability on the involved side was 0.934 (95%CI: 0.863-0.967; $P < 0.001$). The ICC for interrater reliability on the uninvolved side was 0.889 (95%CI: 0.747-0.948; $P < 0.001$). For retroversion measured using the SA, the ICC for interrater reliability on the involved side was 0.934 (95%CI: 0.897-0.970; $P < 0.001$). The ICC for interrater reliability on the uninvolved side was 0.923 (95%CI: 0.853-0.960; $P < 0.001$).

The distribution of measurements was larger on the involved side (Figure 4). Both measurement methods yielded comparable results in the uninvolved shoulder. However, the SA yielded systematically higher values in the deformed humeral head compared to the HCL.

DISCUSSION

We found a significant reduction of humeral retroversion on the involved side compared to the uninvolved side in a consecutive series of patients with internal rotation contractures secondary to BPBI. Additionally, the size of the SSC and IS muscles on the involved side was significantly decreased, as was the muscle ratio (SSC/IS) on the involved side compared to the uninvolved side.

Considering the RV-angles measured, our results are similar to those reported by Pearl *et al.*, which were: 1.8° and 5.8° compared to 20.2° and 18.9°, respectively, depending on the method of measurement. However, the mean age of the study groups differed considerably, 3.2 years old vs 4.3 mo old. Our results suggest that declined humeral version is not something these children slowly grow into. The altered humeral version angle may already develop within the first weeks after birth, when the humerus is probably most prone to altered development caused by altered muscle forces gripping the humeral head. This is supported by the lack of significant correlation found between age and decreased retroversion on the involved side in both studies.

Of further note, the earliest reports by Scaglietti^[11] and van der Sluijs *et al.*^[10] found an increase in retroversion. Scaglietti's study was in a very different era of imaging technology and presented his observations with little quantitative data. van der Sluijs *et al.*^[10] utilized MRI, but nearly two decades ago in a somewhat older age group, when current software tools were not available for image analysis, and the lesser image quality might have influenced measurements. Perhaps these methodological differences explain these contradictory findings.

Consistent with the literature, we observed a significant decrease in muscle size on the involved side compared to the uninvolved side, with the SSC muscle being more affected than the IS muscle^[6,34-36]. However, no significant correlation between the muscle ratio (SSC/IS) and the humeral RV-angle was observed. Nonetheless, the reduction in muscle ratio does not support the theory that the internal rotators overpower the injured (paralyzed) external rotators, but suggests

Table 2 Main results of the muscle cross-sectional area measurements

Muscle area, cm ²	Mean - involved	Mean - uninvolved	P value
Subscapularis muscle	1.56 ± 0.315	2.20 ± 0.372	< 0.001
Infraspinatus muscle	2.35 ± 0.520	2.84 ± 0.495	< 0.001
Ratio	68.51 ± 16.90	78.88 ± 15.45	0.007

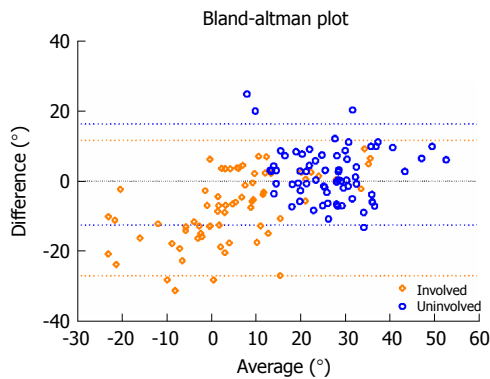


Figure 4 The distribution of measurement in the involved shoulder is larger than on the uninvolved side, indicating measurement differences between the skew axis and humeral center line are larger on the involved side. The blue and orange dotted lines represent the 95% limits of agreement.

that failure of the SSc to grow or develop may result in a contracted SSc, which restricts external rotation.

Another theory could be that the changes in humeral retroversion are partially related to injured muscles outside of the rotator cuff, perhaps those with at least some innervation outside of the original zone of injury. Further study of other muscles is warranted, looking for evidence as to whether they were also injured resulting in impaired growth^[7,37], or whether they recovered so strongly that they overwhelmed their antagonists or are used differently in children with varying levels of recovery.

In addition, animal studies have shown that impaired longitudinal muscle growth and strength imbalance mechanisms are capable of producing shoulder deformities and impaired growth to a somewhat greater extent than muscle imbalance^[8,38-41]. However, this has not yet been related to altered humeral version. For example, impaired growth and increased stiffness of the SSc muscle fibers may have a significant effect on humeral version development. In combination with other internal rotator muscles such as the pectoralis muscle, mechanical stiffness of these muscle fibers may not be directly related to cross-sectional muscle area measurements.

Further research is necessary to elucidate a causal relationship between those mechanisms and shoulder deformities, concerning both the humerus and glenoid, which will help guide clinical treatment decisions for BPBI.

This study has several limitations. The measurements made were based on axial slices of the humerus; measurements made from a 3D-reconstruction, as those performed by Sheehan and others, would have the potential for minimizing errors related to patient

positioning and inconsistent image acquisition. In our studied age group, the humeral head and epicondylar axis are mostly cartilaginous, making 3D-reconstruction of the humeral anatomy much more challenging than in a skeletally mature subject. While the software tools currently exist, they are labor intensive and extremely difficult to implement in clinical practice. Therefore, we chose to utilize methods often used in our clinic setting and shown in a prior publication^[12].

Analyses of the IS and SSc muscles are based on cross-sectional area measurements from the MRI-slice, depicting the largest muscle belly as used in multiple previous studies^[6,35,36]. Capturing the full volume of both muscles would likely have been more informative; however, such software tools were not available to us. Furthermore, muscle thickness was only assessed for the IS and SSc muscles, and the measurement of other external and internal rotator muscles may offer additional insight into muscle behavior and its effect on humeral retroversion in this population.

The most common sequel and focus of surgical intervention in children with BPBI is an internal rotation contracture at the shoulder. These surgical interventions all aim for better function through an improved position of the hand in space. Humeral version undeniably affects hand functionality because with all other factors being equal, decreased humeral version results in an increase of the severity of the clinical presentation of an internal rotation contracture. A large reduction in humeral retroversion at a very young age could be a predictor (or an argument when apparent at an older age) for the necessity of a humeral derotational osteotomy to provide adequate improvement of hand and possibly elbow function. Furthermore, this study shows that secondary osseous changes can occur within several months in this patient population. A prospective study analyzing possible changes in humeral version in this patient population over time would be of interest, as it seems through these results and results from recent studies that changes in humeral version occur early, but that they may not change much after that.

In conclusion, humeral retroversion has a high likelihood of being significantly decreased in this patient population. These findings are relevant for any child under consideration for surgical intervention aiming to improve external rotation, since all other factors being equal, decreased humeral retroversion results in an increased severity of the clinical presentation of an internal rotation contracture. We measured these changes in infants 2-7 mo old and found that altered humeral development

can occur very early in life in a population where internal rotation contractures are apparent.

ARTICLE HIGHLIGHTS

Research background

The existing common treatment options for children suffering from brachial plexus birth palsy all strive for better function of the upper extremity through an improved position of the hand in space. This position is directly related to the humeral version angle.

Research motivation

Since earlier studies did not reveal a correlation between age and decreased retroversion on the involved side, the question remained at what age this anatomic change may occur.

Research objectives

Our objective was to elucidate the timing that decreased retroversion may occur; therefore, we included our youngest patient population (2-7 mo old).

Research methods

We measured humeral version relative to two proximal axes and one distal axis (transepicondylar axis). The proximal axes were: (1) the perpendicular line to the borders of the articular surface (humeral centerline), and (2) the longest diameter through the humeral head. Additionally, cross-sectional areas of the infraspinatus (IS) and subscapularis (SSc) muscles were measured. The difference in retroversion was correlated with the ratio of muscle sizes.

Research results

Retroversion on the involved side was significantly decreased, 1.0° vs 27.6° (1) and 8.5° vs 27.2° (2), ($P < 0.01$), as compared to the uninvolved side. SSc and IS muscle size on the involved side was significantly decreased, 2.26 cm^2 vs 2.79 cm^2 and 1.53 cm^2 vs 2.19 cm^2 , respectively ($P < 0.05$). Additionally, muscle ratio (SSc/IS) on the involved side was significantly smaller compared to the uninvolved side ($P = 0.007$), but was not related to alterations in humeral version.

Research conclusions

Our results show that altered humeral development can occur very early in life in a population where internal rotation contractures are apparent.

Research perspectives

A large reduction in humeral retroversion at a very young age could be a predictor (or an argument when apparent at an older age), for the necessity of a humeral derotational osteotomy, to provide adequate improvement of hand and possibly elbow function. A prospective study analyzing changes in humeral version over time would be of interest to assess the predictive value of decreased retroversion at such a young age, concerning various treatment options (soft-tissue and bony).

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Metallosis following a clip breakage in a total knee arthroplasty implant: A case report

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Abstract

BACKGROUND

Metallosis describes the build-up of metal debris in the soft tissues after a period of metal on metal articulation. This debris can be asymptomatic or lead to catastrophic implant failure, which can present acutely, as in this case, or over a period of time. This report highlights how a metal clip used to hold the polyethylene liner to the tibial base plate broke 5 years after implantation, dislodged from its original position and went on to cause post-operative knee metallosis.

CASE SUMMARY

We present a case of a 63 year old lady admitted to our unit with an acute onset of right knee pain on top of a previous right total knee replacement. There was no associated trauma and examination revealed an erythematous, swollen and tender right knee. Blood investigations went on to display significantly raised inflammatory markers, raising the suspicion of a septic joint. This patient was taken to theatre for a knee arthrotomy and lavage of what was thought to be a septic joint when she was found to have extensive knee metallosis. On further inspection the metal clip, normally used to secure the polyethylene insert to the tibial base plate, had broken, dislodged, and had triggered this response. After the initial washout, this lady went back to theatre, once the appropriate implants were in stock, for an exchange of liner and metal clip.

CONCLUSION

This case highlights this very rare complication which has never been reported in the literature and the success of this patient's management.

Key words: Case report; Metallosis; Total knee replacement; Vanguard®

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Core tip: Metallosis describes the build-up of metal debris in the soft tissues after a period of metal on metal articulation. This can present acutely, as in this case, or gradually. This case report highlights how a metal clip used to hold the polyethylene liner to the tibial base plate broke 5 years after implantation, dislodged from its original position and went on to cause post-operative knee metallosis. The success to this patient's management came from thorough debridement, and replacement of the components involved.

Saad AI, Shahban SA, Fernandes R. Metallosis following a clip breakage in a total knee arthroplasty implant: A case report. *World J Orthop* 2018; 9(12): 300-303
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INTRODUCTION

Metallosis is a rare condition that has been recognised to affect both knee and hip arthroplasties. The most common cause leading to this malady is abrasive wear of the polyethylene component, inadvertently allowing two or more of the metal components to come into contact. This subsequently leads to a serious and debilitating synovial reaction.

Though the majority of cases documented in the literature of metallosis involve the wear of the polyethylene component; we present a rare and interesting case of metallosis in the knee following breakage of the metal clip used to hold the polyethylene insert of a Vanguard® implant in place. This consequently allowed the femoral and tibial components to come into contact leading to the acute metal induced synovitis.

CASE PRESENTATION

Case report

A 63 years old lady had a right total knee replacement (TKR) in 2013 using the Vanguard® knee system - Biomet implant. She was admitted into hospital in March 2018 - approximately five years following her initial TKR. She presented with an insidious and acute onset of worsening right knee pain and swelling, not associated with any trauma. The pain was affecting her mobility, limiting her ability to weight bear on that joint.

On clinical assessment, she had an erythematous and fluctuant right knee with a moderate joint effusion. Along with this, she had a tender joint line with a limited range of movement. There was no evidence of wound breakdown, equally in 2013 following her primary procedure, she had an uncomplicated recovery period. She had a core body temperature of 37.3 °C, with no accompanying fevers or rigors, and the rest of her

physiological markers were unremarkable.

Her initial blood investigations revealed significantly raised inflammatory markers with a white cell count (WCC) of $20.27 \times 10^9/L$, neutrophils of $16.68 \times 10^9/L$ and C - reactive protein (CRP) of 186 mg/L, suggesting an acute infection. Radiographs of the knee showed a relatively well positioned in-situ TKR, with no evidence of loosening, with the possibility of a joint effusion (Figure 1A and B).

Given this patients history, examination and biochemical findings, a right knee septic arthritis could not be excluded, and as such she was taken to theatre for a knee arthrotomy with a view to debride the joint, and potentially replacement of the polyethylene liner.

After the initial arthrotomy was made, significant purulent, dark coloured fluid extruded from the joint. The knee joint was formally opened and at this point no pus was seen, however there was a significant amount of metallosis debris deeply embedded into the soft tissues surrounding the knee prostheses (Figure 2A). On further inspection, it was clear that the metal clip which is normally used to secure the polyethylene insert to the tibial base plate had broken and dislodged (Figures 2B and C). Despite this broken metal clip, the polyethylene liner was still in its original position, and on further examination the femoral, tibial and patella implants were all well fixed with no evidence of loosening. There was also no evidence of significant macroscopic wear of the femoral and tibial components.

The broken metal clip was retrieved successfully and in whole (part being dislodged and part being well fixed in the polyethylene liner). The Vanguard® TKR system is no longer used in our trust, and consequently we were unable to replace the liner and metal clip. This lady therefore went on to have a thorough soft tissue debridement of her metallosis and lavage with copious normal saline solution. She later had a second staged procedure (after a total of 18 d) at which point we were able to obtain the correct implants, and thus provide her with a new polyethylene liner and metal clip to secure it in place. In the interim, between stages, she was prescribed a course of two grams of intravenous flucloxacillin antibiotics (to complete a six week course) and was restricted with her weight bearing, to prevent polyethylene liner displacement.

Superficial and deep tissue samples from the time of her 1st procedure did not grow any organisms. The histology report demonstrated areas of black necrosis with reactive fibrosis, a giant cell foreign body reaction triggered by black, irregular metallic particles, confirming the diagnosis of metallosis.

OUTCOME AND FOLLOW UP

Post-operatively, the patient's inflammatory markers started to improve with a fall in the CRP to 52 mg/L and WCC of 12×10^9 . There was also marked improvement in her symptoms, pain and range of movement of the knee. She was later discharged whilst being able to fully

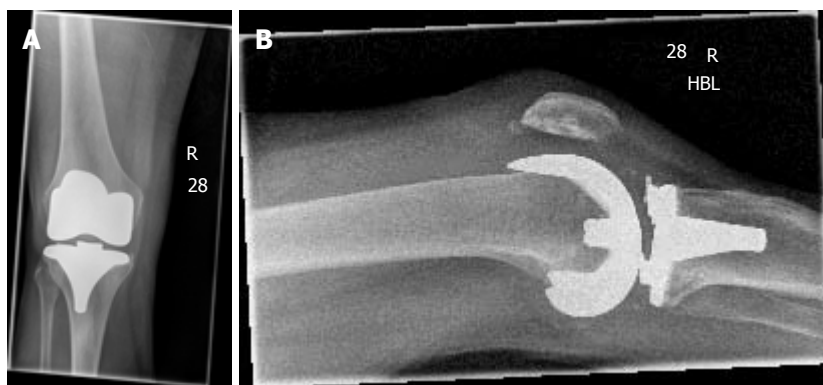


Figure 1 Initial radiographs of the right knee. A: Anterior-posterior radiograph of the right knee; B: Lateral radiograph of the right knee.

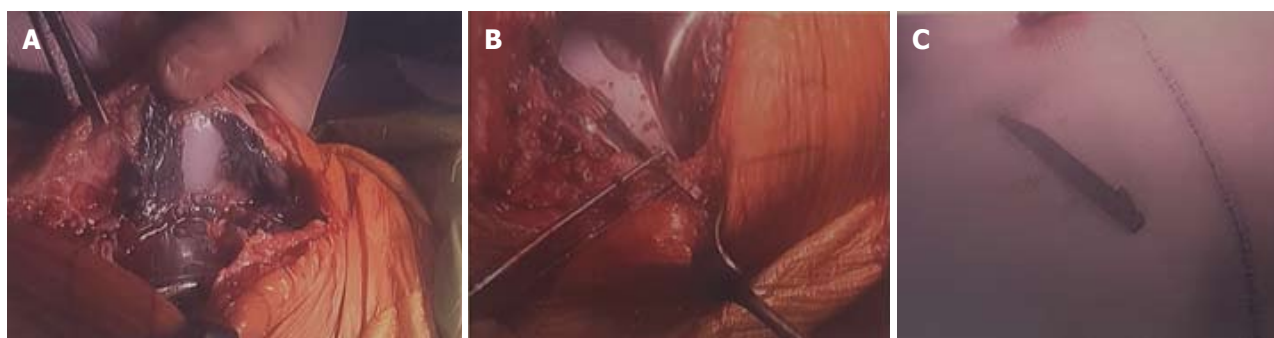


Figure 2 Intraoperative images of the soft tissues surrounding the *in-situ* total knee replacement. A: Intraoperative Image of extensive soft tissue metallosis; B, C: The retrieved broken metal clip.

weight bear and with a much improved knee. At the six week stage, in the outpatient clinic, she had complete resolution of her symptoms and was happily discharged from clinic.

DISCUSSION

Metallosis is an uncommon synovial reaction that can lead to serious complications and almost always requires revision surgery. It is therefore critical to understand the causes that lead to this condition. Avoidance of this essentially comes down to trying to ensure that the individual metal components of any part of the prosthetic joint are not allowed to come into contact and abrade against each other. Most case reports in the literature document the development of metallosis following significant wear of the interposed polyethylene component^[1]. In this report we found no significant wear of the polyethylene insert, but rather, ensuing metallosis which was allowed to occur due a metal clip which had broken and dislodged, allowing for metal-on-metal (MOM) abrasion of the components.

As the inflammation progresses, often over a prolonged period of time, patients with knee metallosis usually present with gradual worsening knee pain and, occasionally, a noticeable rash (indicating necrosis). Prosthetic dislocation is often a late sign and demonstrates significant polyethylene wear^[2]. This almost always goes

on to require revision surgical intervention.

Different companies have different ways in which one can secure the polyethylene liner to the tibial base plate. In the case of the Vanguard® TKR system, one is required to slide the metal clip through both the liner and tibial component, thus allowing for a secure hold of the two. Clip breakage is not a recognised complication of TKR, and very rarely occurs. One would expect that when the clip breaks, this disrupts the position of the polyethylene component, which would ultimately lead to displacement or even dislocation of the knee joint. In our case, though we found the insert to be stable, we concluded that the broken and loose part of metal clip was abrading the metal back components of the joint, and thus triggering the metallosis inflammatory reaction.

When there is a suspicion of post-operative knee metallosis, imaging may help in coming to this diagnosis. Described in the literature are the metal-line sign and the cloud sign which occasionally can be seen on plain radiographs^[2,3].

With regards to the pre-operative radiographic images (Figures 1A and B) it was not immediately recognised that the clip had broken and moved out of position. In retrospect, there is a suspicion that the broken metal clip is visible in the initial set of radiographs. Whether or not pre-operative recognition would have aided in planning is debatable, as the decision to debride the joint was made on clinical grounds of a possible diagnosis of septic

arthritis. Liner exchange could not be carried out at the first instance due to non-availability of the insert and clip as these components were no longer used by the trust - something which, with more detailed pre-operative imaging, potentially could have been planned for and potentially could have allowed her to have a single staged procedure.

CONCLUSION

Metallosis is most commonly caused by wear of the polyethylene insert, leading to a chronic inflammatory process with signs that may or may not be easily identifiable on plain radiographs. Septic arthritis is potentially fatal and thus requires a thorough work up. Once septic arthritis is excluded, early diagnosis of metallosis is key and often requires revision surgery in terms of debridement with or without implant exchange.

We present a rare case of metallosis from what was thought to be a robust mechanism of polyethylene liner stabilisation. We urge all clinicians to bear this in mind when dealing with prostheses which have the potential to allow any form of MOM interaction(s).

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